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DEVELOPMENT OF AIRS:AMS TRANSPORTATION EMISSIONS METHODOLOGY

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16. ABSTRACT The paper discusses the National Emissions Data System (NEDS) Mobile Source methodology, the State Implementation Plan (SIP) Mobile Source methodology, differences and problems between the two methodologies, and the research program that will result in an improved Mobile Source methodology that will serve both the NEDS and SIP emission inventory objectives. The methodologies developed by this research program will reside in the Area and Mobile Source (AMS) Subsystem of the Aerometric Information Retrieval System (AIRS). EPA annually estimates emissions of the five criteria pollutants--particulates (TSP), SO2, NOx, reactive volatile organic compounds (VOCs), and CO. Historically, these emission estimates were stored in NEDS as point or area source emissions. Area sources usually include all mobile sources and any stationary sources too small, difficult, or numerous to classify as point sources. In NEDS, an area source is defined as a source that emits < 100 tons/year of a criteria pollutant. Areas that are in non-attainment with the National Ambient Air Quality Standards (NAAQS) are required to develop SIPs for use in the demonstration of progress toward meeting these standards. The major objectives of AIRS include providing storage and reporting capability for air quality, emissions, and enforcement data required by EPA regulations and the Clean Air Act.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Nitrogen Oxides	Pollution Control	13B
Emission	Carbon Monoxide	Stationary Sources	14G
Information Retrieval	Organic Compounds	Mobile Sources	07C
Particles	Volatility	Volatile Organic Compounds (VOCs)	05B 20M
Sulfur Dioxide			07B

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INTRODUCTION

The U.S. Environmental Protection Agency (EPA) annually estimates emissions of five criteria pollutants, particulate (TSP), sulfur dioxide (SO_2), nitrogen oxides (NO_x), reactive volatile organic compounds (VOCs), and carbon monoxide (CO). Historically, these emission estimates were stored in the National Emissions Data System (NEDS) as point or area source emissions. Area sources usually include all mobile sources and any stationary sources too small, difficult, or numerous to classify as point sources. In NEDS, an area source is defined as a source that emits less than 100 tons/year of a criteria pollutant.

This paper discusses the NEDS Mobile Source methodology, the State Implementation Plan (SIP) Mobile Source methodology, differences and problems between the two methodologies, and the research program that will result in an improved Mobile Source methodology that will serve both the NEDS and SIP emission inventory objectives. The methodologies developed by this research program will reside in the Area and Mobile Source Subsystem (AMS) of the Aerometric Information Retrieval System (AIRS).

NEDS methodology is currently used to estimate emissions for the approximately 3200 counties or county equivalents in the U.S. and its territories. While the methodology is applied and assumed to be valid on a national scale, a major deficiency of the current NEDS methodology is its inability to be responsive to local conditions. In addition, the original NEDS Area/Mobile Source methodology dates back to the 1973-1974 timeframe. A large portion of the background information used for the development of the current methodology and algorithms is the census data for 1960 (e.g., population, housing, manufacturing). These methods have remained relatively unchanged for the past 15 years and need to be upgraded.

Areas that are in non-attainment with the National Ambient Air Quality Standards (NAAQS) are required to develop SIPs for use in the demonstration of progress toward meeting these standards. State and local air agencies are responsible for the generation of SIP inventories for use in these plans. While new Clean Air Act amendments continue to call for the development of SIP inventories, SIP inventory techniques suffer from problems similar to those of the NEDS methodology (e.g., old methods, inconsistent application of methods).

AIRS has been under development by EPA's Office of Air Quality Planning and Standards (OAQPS). The major objectives of AIRS are: to provide storage and reporting capability for air quality, emissions, and enforcement data required by EPA regulations and the Clean Air Act; to replace existing systems used to store and report these data; to promote information sharing among EPA and State and local air agencies; to provide the ability to interact with other EPA data bases; and to provide enhanced data processing services to the EPA and State/local user communities. Of the four components of AIRS, three (the Air Quality Subsystem, the Geographic/Common Subsystem, and the Facility Subsystem) are now in operation. The last component of AIRS to be developed is AMS. As noted above, the AMS component of AIRS will be the repository for the newly developed methodologies which result from this research program.

THE NEDS TRANSPORTATION SECTOR

Figure 1 illustrates the different components of the transportation sector including highway vehicles, off-highway vehicles, and gasoline marketing operations as currently defined in NEDS. Highway vehicles include light duty gasoline vehicles (passenger cars), light duty gasoline trucks, heavy duty gasoline trucks, and heavy duty diesel vehicles. Off-highway vehicles include construction equipment, agricultural equipment, recreational vehicles (three- and four-wheel

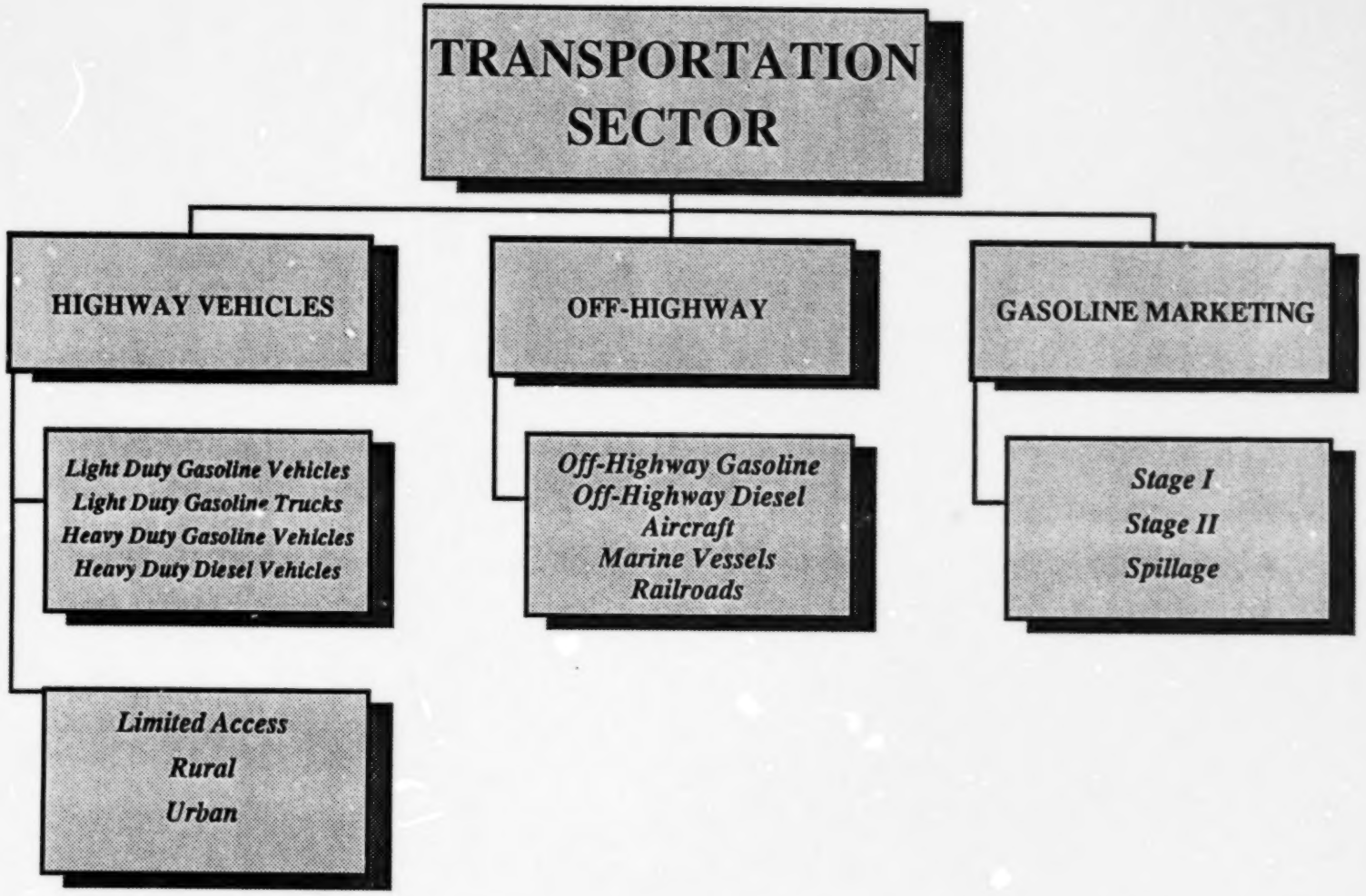

Figure 1. Definition of the NEDS Transportation Sector

drive all terrain vehicles as well as snowmobiles), lawn and garden equipment, aircraft (commercial, private, and military), marine vessels, and railroads. Gasoline marketing operations include evaporative losses from the distribution of both gasoline and diesel fuel. These include emissions from Stage I (filling gas station tanks) and Stage II (filling vehicle tanks at gas stations) operations but do not include emissions from bulk terminals and plants which are currently inventoried as point sources.

The primary pollutants from the transportation sector are NO_X, VOC, and CO. NO_X and VOC chemically interact in the atmosphere to form ozone and are therefore of primary concern for the study of ozone non-attainment areas. Figure 2 illustrates the relative contributions of NO_X, VOC, and CO as reported in the 1985 NAPAP Emissions Inventory.[1] Almost half of the NO_X and VOC anthropogenic emissions are from the transportation sector, with the largest subcategory being highway vehicles. For NO_X, the "other" category is largely composed of stationary source combustion sources, especially the utility sector. The "other" category for VOC is primarily composed of industrial process emissions including the evaporation of solvents. Transportation sources dominate the CO emissions, again with stationary fuel combustion sources composing the majority of the "other" category.

The short term trends[2] in emissions are illustrated in Figure 3. As shown in Figure 3, annual estimates of vehicle miles traveled (VMT) are steadily increasing over time while emissions of VOC are decreasing. This is the result of increased fuel economy in automobiles through more efficient fuel combustion, lighter weight vehicles, and the addition of catalytic converters. However, this trend in emissions is not consistent with trends in ozone ambient air quality data. This lack of consistency between emission trends and ambient air quality data may be due to meteorology, photochemical reactivity considerations, uncounted emission sources, etc., but may also in part be due to poor mobile source emission inventory procedures.

Existing NEDS Methodology

Highway vehicle emissions are calculated at the county level by multiplying VMT by emission factors.[3] Currently, NEDS estimates emissions for four vehicle classes--light duty gasoline vehicles (LDGV), light duty gasoline trucks (LDGT), heavy duty diesel trucks (HDDT), and heavy duty gasoline vehicles (HDGV)--and three speed classes--limited access roads (50 mph), rural roads (45 mph), and urban roads (19.6 mph). The VMT are reported by approximately half of the states; for the remaining states, VMT are calculated based on fuel consumption, vehicle registration data, and average fuel efficiencies. Emission factors are calculated by running the latest version of the MOBILE model.[4] This model uses information on ambient temperature, vehicle data (age, type, weight, etc.), and operating conditions to calculate emission factors.

Emissions from the remaining categories (off-highway gasoline vehicles, off-highway diesel vehicles, railroad locomotives, aircraft, marine vessels, and gasoline marketing) are estimated using activity-level data, such as fuel consumption, which have been allocated to the county level. Activity data are multiplied by AP-42 emission factors[5] to produce county-level emissions estimates.

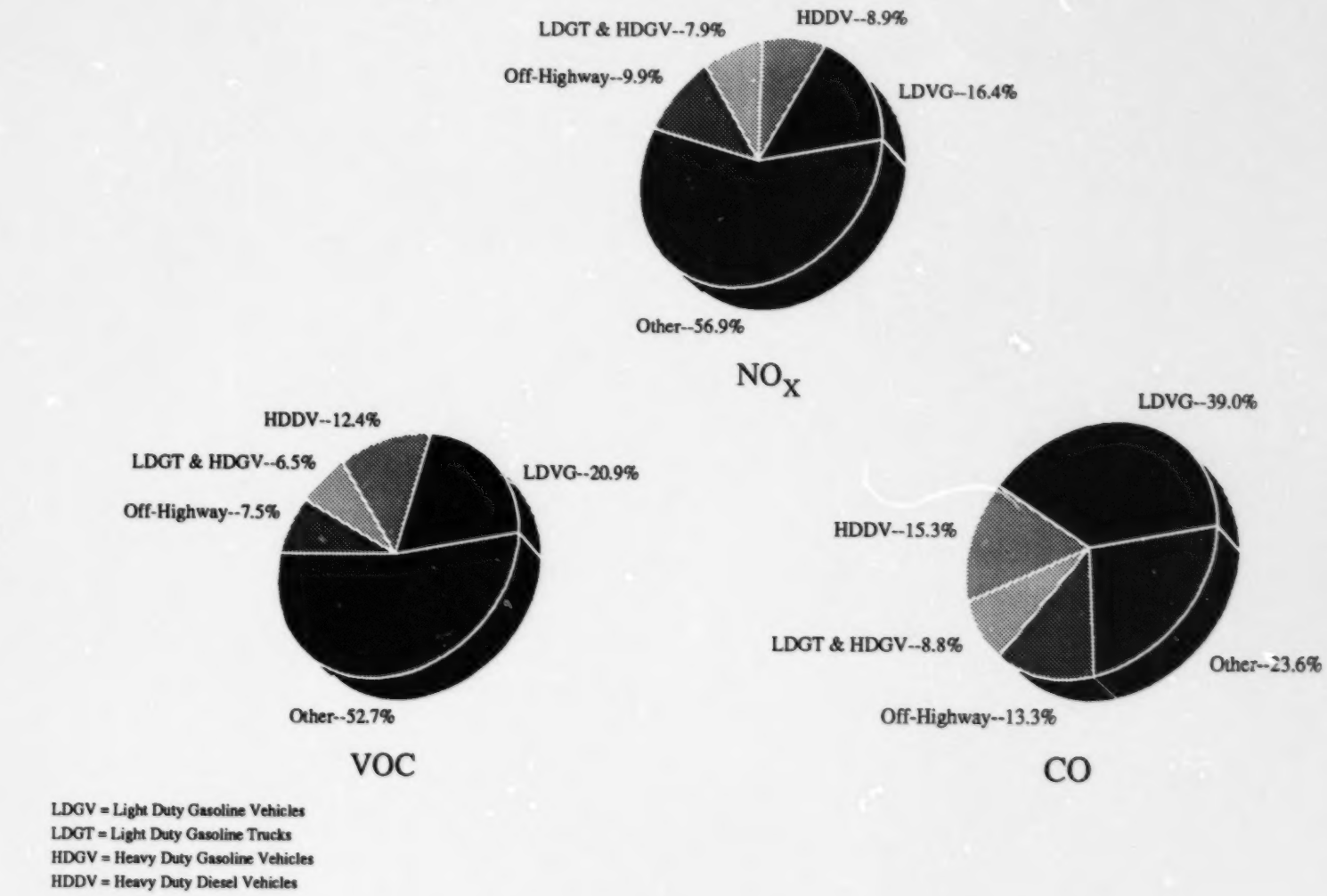

Figure 2. 1985 Emissions of NO_X, VOC, and CO by Source Category

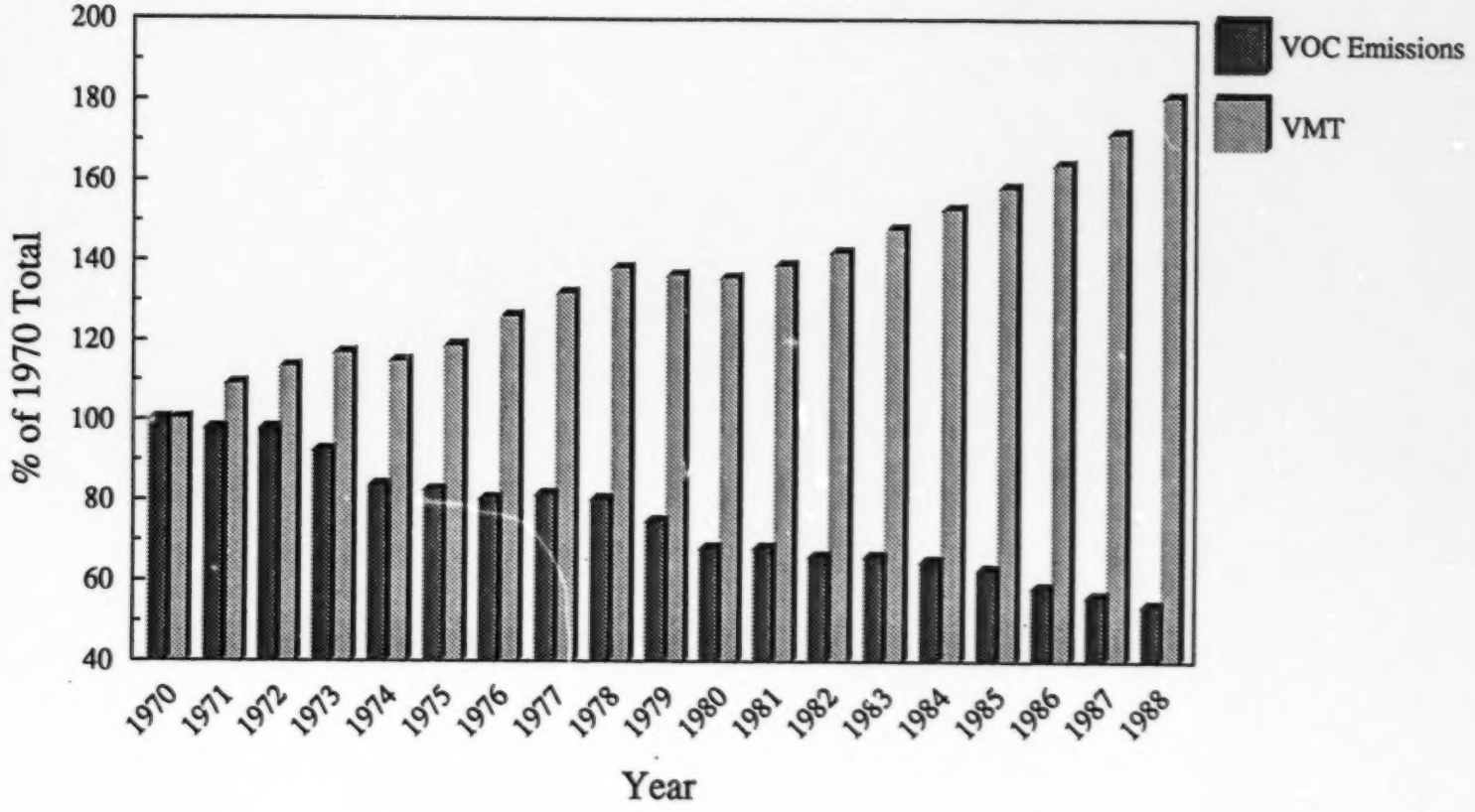

Figure 3. Trends in National Vehicle Miles Traveled and VOC Emissions, 1970 To 1988

Existing SIP Methodology

Current guidance for the development of SIP inventories[6] allows for different methods depending on the needs of the area. SIP guidance calls for an area to estimate emissions from all eight highway vehicle types as delineated by the MOBILE4 computer model. However, one area may choose to estimate emissions from highway vehicles using 5 speed classes while another area may choose to estimate emissions using 12 speed classes. Moreover, most areas have different models or methods for estimating VMT and speed class. These different methods lead to inconsistencies among SIP Mobile Source inventories. Highway vehicle emission factors are calculated using the MOBILE4 computer model for all of the U.S. except for California which uses the EMFAC7D model developed by the California Air Resources Board (CARB).

Emissions from the remaining categories (off-highway gasoline vehicles, off-highway diesel vehicles, railroad locomotives, aircraft, marine vessels, and gasoline marketing) are estimated using fuel consumption data, vehicle or equipment population data, or tax revenue information. Activity data are multiplied by AP-42 emission factors[5] to produce county-level emissions estimates.

OBJECTIVES OF RESEARCH PROGRAM

The primary use of both the NEDS and SIP emission inventory methodologies is the production of national and urban scale emissions inventories, respectively, whose results may be used by modelers, policy analysts, control strategists, etc. While the uses of the two inventories are similar, the methodologies are very different. This difference causes problems when attempting to compare results between the different modeling groups, emission inventory groups, policy groups, or control strategy groups within EPA.

The objectives of the research program are to develop a practical, workable, accurate, and consistent emission inventory methodology that can be applied to all areas of the nation for both the national (NEDS) and local (SIP) inventories. Most of the past problems between the national (NEDS) and local (SIP) inventories have been because of this lack of consistency and uniformity between the two emission inventory procedures. In addition, it is clear that the new Clean Air Act will rely more heavily on emission inventories than in the past to track progress toward attaining the national ambient air quality standards. Therefore, it is important that the EPA develop sound emission inventory procedures to meet this new requirement.

ELEMENTS OF RESEARCH PROGRAM

The research program will address all of the subcategories within the transportation sector with special emphasis on the larger emitters. Figure 4 illustrates the major components of the research. Several of the program areas have similar goals: for example, the improvement of source characterization, emission factors, and estimation methods. Other components are specific to the subcategory being studied.

Highway Vehicles

The highway vehicle research includes improved source characterization, better guidance in the use of MOBILE4 to generate emission factors, improved VMT estimates, and research into projection factors and speciation profiles.

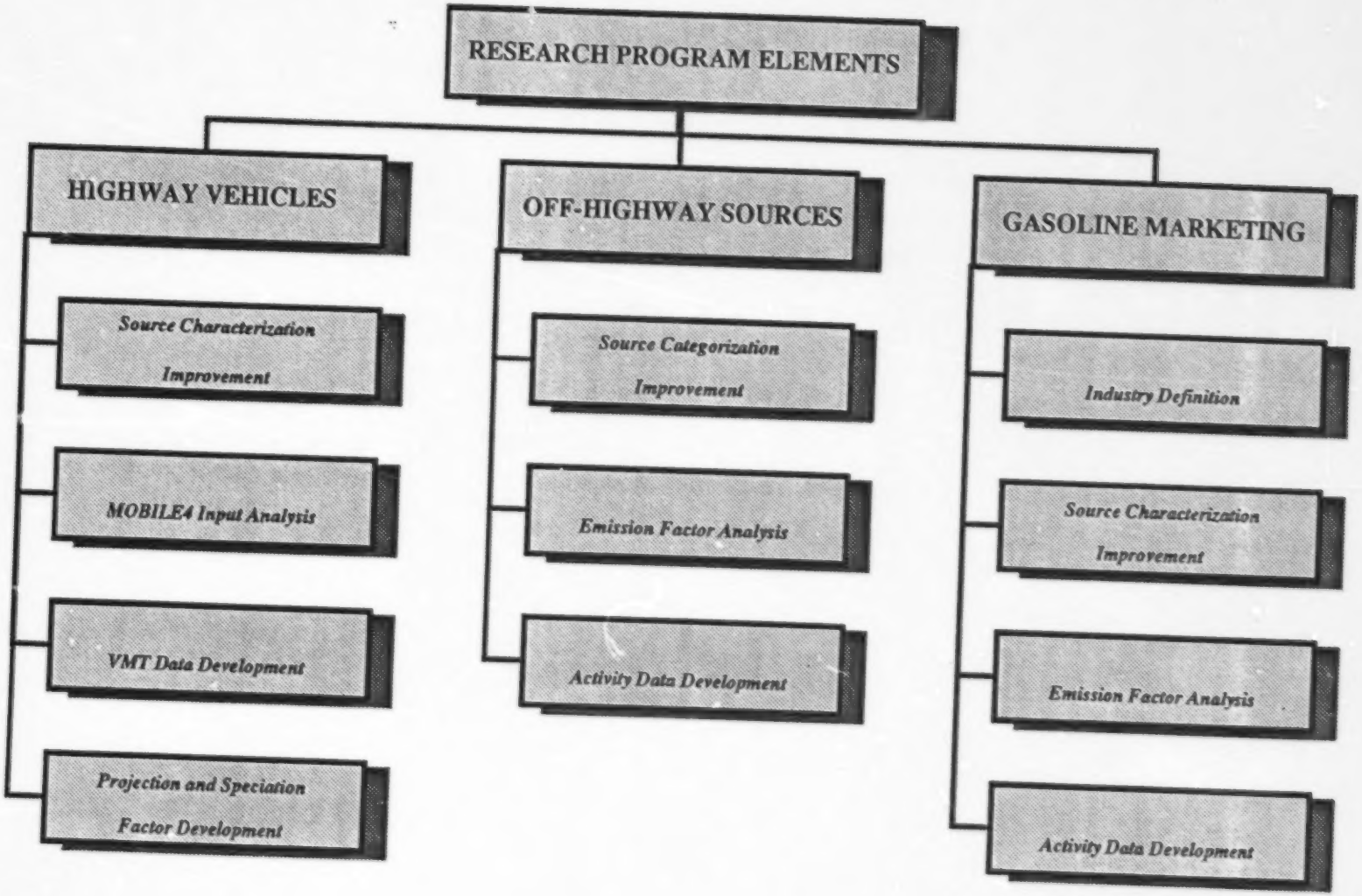

Figure 4. Definition of Research Program Elements

Source Characterization Improvement. The current NEDS methodology has 12 highway vehicle categories (4 vehicle types at 3 road/speed classes) that were established in the early 1970s. These categories do not reflect the evolution of highway traffic including the emerging importance of light duty diesel vehicles, the increase in the speed limit to 65 mph for limited access roads, or the increased congestion in urban areas with the resulting decrease in speeds. In addition the current methods do not allow for variation in speed for the same road type in different geographic areas. An important component of the research is the definition of appropriate vehicle types to reflect current and future conditions. The new Clean Air Act is expected to facilitate the introduction of alternative "clean" fuels such as liquified petroleum gas (LPG) or methanol.

MOBILE4 Input Analysis. Each new update of the MOBILE emission factor model introduces additional options for users to tailor the resultant emission factor to their needs. An analysis of MOBILE model options and their relative impact on emission estimate calculations will be a part of the research project. Because this research effort must provide for a methodology that will be useful for the next 5 to 10 years, inputs that may have more effect in future years will also be investigated. For example, temperature and Reid Vapor Pressure (RVP) have a dramatic effect on emissions today, but with the introduction of on-board controls, these effects may be minimized.

Vehicle Miles Traveled. VMT data are critical in the estimation of emissions from highway vehicles. Three areas of research will be conducted. First, the VMT models that are used to generate data by state agencies, the federal government, and highway planning agencies will be analyzed to evaluate the current status of VMT estimates. This analysis will include research into the validation and calibration of these models. Second, an ideal VMT model that is cheap, easy to operate, and will provide accurate VMT estimates for varying spatial scales is the goal of this project. Finally, a quality control plan for VMT estimates will be developed to ensure that the numbers are reasonable and in agreement with VMT estimates made by different organizations.

Projection and Speciation Factor Development. Highway vehicle sources may become an increasingly large component of NO_x, VOC, and CO emissions due to increases in traffic volume. Projection inventories are used to analyze different control strategies. There is a need for the development of consistent and accurate methods for developing projection factors.

Speciation profiles are currently used to disaggregate both the NO_x and VOC emissions into their constituent chemical species. Currently, NO_x emissions are assumed to be 95% NO and 5% NO_2 based on early research into the nature of NO_x emissions from boilers. Highway vehicle emissions have different chemical constituents for exhaust versus evaporative emissions. VOC emissions can be speciated using the speciation profiles[7] or algorithms built into MOBILE4. Research is required to confirm the NO_x profile and to reach consensus on the different VOC profiles.

Off-Highway Sources

In the NEDS system, 10 area source categories for off-highway vehicles currently represent 10% of the NO_x and 7% of the VOC in the 1985 NAPAP Emissions Inventory.[1] In addition to improving the methodology for these categories, the adequacy of this source characterization will be analyzed and missing categories will be identified.

Source Categorization Improvement. Improved source characterization includes better definition of existing categories, if warranted, as well as the identification of missing sources. Categorization that may be enhanced includes cruise modes for aircraft. Examples of missing sources are: helicopters; support vehicles at airports, railyards, and seaports (cranes and trucks); weekend and commercial gardening equipment (rotary tillers, portable generators, snowblowers, and leaf blowers); weekend vacationer equipment (jet skis); and weekend handyman equipment (gasoline powered chainsaws). An additional question that needs to be addressed is the disaggregation of fuel categories (i.e., gasoline versus diesel) into component categories (agriculture, construction, industrial, commercial, residential).

Emission Factor Analysis. The adequacy of the AP-42 emission factors will be assessed especially for farm equipment and off-highway motorcycles. Although research into emission factor development may be outside the scope of this research effort, the identification of problems with current factors is critical to the development of a credible methodology.

Activity Data Development. Existing sources of activity data will be reviewed to determine their sufficiency for this program. Alternative sources of data will also be researched to determine if they are easier to use or provide more accurate information. One possible improvement is the use of fuel consumption instead of, or in conjunction with, vehicle populations. Vehicle populations for marine vessels, farm equipment, construction equipment, and lawn and garden equipment will be updated to provide accurate and consistent values for both the NEDS and SIP programs. In addition, sources for air activity data (specifically military operations) will be researched. Finally, railroad track miles and the inland waterway miles will be reviewed and possibly updated.

Gasoline Marketing

Gasoline marketing operations include Stage I and Stage II operations. Research into emissions from this subcategory will begin with a definition of the industry to determine the boundaries of this research and the overlap with other source categories. Second, source characterization will be improved. Third, emissions factors will be evaluated. Fourth, improvements in the activity data will be identified. Finally, miscellaneous problems that have been uncovered in current SIP guidance will be addressed.

Industry Definition. Gasoline marketing operations impact many source categories including highway vehicles, off-highway vehicles, petroleum liquid storage, and transportation. Evapora-

tive emissions from the transfer and storage of fuel are covered under this category; however, information on the quantities and types of fuels used by other groups can improve or provide QA methods for emissions from the other source categories.

Source Characterization Improvement. The current source categorization provides for emissions from large bulk plants and terminals as point sources and smaller facilities operating the same types of businesses as area sources. The addition of new source categories for "clean" fuels such as ethanol or ethanol blends may be warranted. In addition the application of control devices must be factored into the source categories.

Emission Factor Analysis. The current emission factors in AP-42 for evaporative emissions from gasoline marketing operations do not account for temperature and RVP changes. In addition, there is a lack of guidance on how to inventory gasoline spillage. The effects of local vapor control strategies are not accounted for in the national inventory, although SIP inventories include their effects. MOBILE4 has a Stage II refueling emission factor component that differs from the AP-42 emission factor procedure. Both MOBILE4 and AP-42 will be investigated and the method that provides the more accurate emission factors will be selected for use in the new emission inventory procedures. Coordination with other transportation sources in terms of RVP and temperature data must be maintained to ensure that consistent numbers are being applied.

Activity Data Development. The sources of fuel distribution data will be researched. Again these data should be applicable to the estimation of evaporative emissions and should provide insight into the categories that create emissions based on the consumption of the fuel thereby helping to identify missing sources. This task provides for the determination of the best source of activity data on fuel sales and/or shipments. This activity will be coordinated with the fuel consumption projects to ensure that the data are consistent across the inventory. Possible sources of data include tax receipts at the state or federal level.

CONCLUSIONS

Transportation sources are an important component of current emission inventories. Accurate estimates are needed on both national and local levels to support the activities of the U.S. EPA (e.g., urban airshed modeling, regional modeling, control strategy studies). Two emission inventories are currently developed within the Agency using different methodologies resulting in different emission estimates. As a result, these differing methodologies lead to misunderstandings and confusion over which method and emission estimate is the more correct. A research program is currently under development to improve the estimation methodology for transportation sources. This methodology will be applicable to both national and regional inventories.

Elements of the research program include improved source characterization to maximize the detail available to the user community; identification of problems associated with the emission factors and improvements to the factors wherever possible; identification of alternative forms of activity data where available; and development of improved projection and speciation

factors for use in detailed atmospheric modeling studies. While this research program has numerous elements, the main goal of the research is the development of a single method that will meet the needs of local users but is also applicable at the national level.

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